Porth Trefadog RIGS site

NRW RIGS no. 194 [SH 28958 85835]

GeoMôn Global Geopark original webpage

RIGS Statement of Interest:

Porth Trefadog RIGS site contains the best exposures of pillow lavas from the Church Bay Tuffs and Skerries Grits Precambrian rocks in Anglesey which have been subject to metasomatic alteration. New research suggests that this group of rocks should be included in the Gwna Group. The rocks are thought to have erupted on the sea bed, probably on an oceanic ridge, prior to their translocation and descent into a deep sea trench. They are important for showing the alteration of some of the pillows to dolomite. More rarely, there appears to be evidence of deep ocean activity with the introduction of manganese and copper with silica. The appearance resembles the siliceous sinter accompanied by other minerals found at Parys Mountain and attributed to exhalative deposits. At this site, the copper and manganese are present in very small quantities. These lavas and their associated sediments descended into the subduction zone (trench), where they became attached to the inner (continental) wall of a trench. As such, these rocks represent slices of ocean floor, and have been shown to possess the geochemistry of ocean-floor basalts. Their current location can be explained as part of a deformed wedge of sediments and lavas, scraped off the descending plate as it dropped down into the oceanic trench. It then attached itself to the margin of the continental crust. The rocks attained their present position when they were accreted on to continental material. The lavas are therefore part of a tectonic, rather than a stratigraphic sequence. These exposures of Precambrian-age rocks are similar to rocks currently being subducted in Japan and, as such, provide important evidence suggesting plate tectonic processes of similar character have been operative throughout geological time. These spilites and associated sinter appear to have a tectonic contact with the New Harbour Group of rocks to the south.

Geological setting/context: The Precambrian basement rocks of Anglesey and south-west Ll■n can be divided into several discrete groups, all of which were juxtaposed along a series of steep, brittle and/or ductile faults and shear zones (e.g. Dinorwic and Aber-Dinlle faults; Berw, Central Anglesey and Ll■n shear zones) collectively referred to as the Menai Strait Fault System (MSFS). First, the Monian Supergroup consists of a thick sequence of polydeformed metasediments and meta-igneous rocks, comprising the South Stack, New Harbour and Gwna groups, the latter representing the type example of a large-scale submarine debris flow or mélange said by some researchers to be of Lower Cambrian age. Ongoing research, however, may suggest a much older date for the Gwna Group with possible Cambrian ages being put forward for the South Stack metasediments. Second, the Coedana Complex of central Anglesey comprises high-grade metasediments, amphibolites and gneisses, and low-grade, thermally metamorphosed hornfelses adjacent to a granite (Coedana Granite), which has recently yielded a late Precambrian zircon age of 614 ± 4Ma. Third, a belt of schists and metabasites displaying blueschist facies grade of metamorphism lies within the MSFS. The metabasites exhibit a strong mid-ocean ridge basalt signature and have yielded ages of 580–590Ma. Fourth, the Sarn Complex in Ll■n comprises metagabbros and granite rocks which occur to the south-east of the Ll■n Shear Zone (LSZ), a continuation of the MSFS, which separates these igneous rocks from low-grade Monian mélange to the north-west. A late Precambrian zircon magmatic age of 615 ± 2Ma has been obtained from a metagabbro of the LSZ. Fifth, on the mainland of north-west Wales, the Arfon Group comprises a thick sequence of tuffs and volcaniclastic rocks, dated at 614 ± 2Ma, which are conformably overlain by late Lower Cambrian siltstones. Correlatives of the Arfon Group may occur as isolated outliers on Anglesey and, if proven, would provide an important potential lithostratigraphical link across the MSFS. The stratigraphical correlation between the various units has proved highly controversial. The recent recognition of mylonitic rocks, for example in the LSZ, emphasises the presence of tectonic contacts and indicates that each component may represent a so-called ‘suspect terrane’ which was transported laterally into position along the major faults and shear zones. Ongoing unpublished research suggests, that Anglesey’s Precambrian rocks accumulated in accretionary prisms, providing a tectonic sequence rather than a stratigraphic sequence which was formerly accepted. This new research would reverse the accepted stratigraphic order of the bedded succession, the South Stack Group, the New Harbour Group and the Gwna Group established for the island by Robert Shackleton. This Precambrian basement later formed

the north-west margin of the Lower Palaeozoic Basin, the initiation of which was contemporaneous with Arfon basement terranes and was completed at least by early Ordovician times since an unconformable Arenig overstep sequence has been identified at several localities such as Wig Bach, Parwyd and Mountain Cottage Quarry. The Arenig sequence of Anglesey and Ll■n is considerably less deformed and metamorphosed than the underlying basement, although this distinction is not everywhere obvious.

Network context of the site: Porth Trefadog is a critical component of a network of three RIGS which represent pillow lavas and demonstrate key features of Greenly's Precambrian rocks in Anglesey. Porth Dinllaen and Mynydd Carreg also belong to this category of Precambrian Reference sites but are located in Lleyn.. The pillow lavas lie between the northern end of the beach known as Porth Twyn-mawr, an area of New Harbour Group rocks and Porth Trefadog which comprises rocks from the Church Bay Tuffs and Skerries Grits. The bay to the south, Porth Trwyn-mawr contains another spilite Precambrian reference site (Cliperau), but lies within a different group of Precambrian rocks known as the New Harbour Group. The rocks comprise fine-grained spilites with distinguishable pillow forms, though not as perfectly preserved as those seen in Newborough Forest. They appear to have been affected by some metamorhism but are less altered than the Cliperau exposures. This locality is important for demonstrating the effect of metasomatism, where hot liquids have been extruded from the mantle and lower oceanic crust. The liquids alter the normal spilitic composition of the pillows and also produce new minerals , such as copper, Manganese and dolomite. The geochemistry of these basic rocks shows that they were originally mid-ocean-ridge-basalt (MORB), representing a slice of Precambrian oceanic crust. The fresh lavas were subducted into oceanic trenches along destructive plate margins. It is possible that all Precambrian rocks in southern Britain were part of the same Avalonian subduction system as Nova Scotia, Newfoundland and Canada. Apart from the spilite (pillow lava) at Porth Trefadog, four other 'pillow lava' RIGS have been chosen for their varying importance, Newborough Forest in the Gwna Group of Precambrian rocks where the pillows are perfectly formed and little altered, and Cliperau, in Greenly's New Harbour Group which represents pillows having been subjected to regional metamorphism. Castellior Farm and Pentraeth Road Cutting (both in Greenly's Gwna Group) now termed the Eastern Schist Zone (Penmynydd) are examples of pillows which have suffered regional metamorphism and are transitional to the glaucophane schists (pillow lavas subjected to intense pressures at low temperatures) to which they have been altered. The latter two, retain relict pillow forms in parts of the intrusions and both have a dual interest as they belong to two Precambrian Reference Section sub-groups, glaucophane schists and spilites (pillow lavas). Therefore, only one report for each of the two sites has been written. Mynydd Llwydiarth, to the east of the road cutting is totally overgrown and will not be described unless a forest clearance programme is undertaken. In addition, two Lleyn sites are included in the spilite category, Porth Dinllaen and Mynydd Carreg.

To select RIGS to demonstrate the Precambrian evolution of Anglesey and Ll■n, three separate networks were devised. These are: 1. Precambrian stratigraphy and structures. This network includes two sub-sets: a) Precambrian sedimentary structures; and b) tectonic structures, such as folds and faults, which may have occurred during a tectonic event in Precambrian times or later, for example, during the Caledonian Orogeny; 2. Precambrian palaeontology which includes any life-form and trace fossil, such as stromatolites, sponge spicules, worm burrows and bioturbated metasediments. Some current research suggests that some of these fossils may be Cambrian or even Ordovician in age,although other geologists dispute this. As these life-forms were previously held to be Precambrian in age, they have been included in this category; and 3. Precambrian reference sections. These aim to represent all important Precambrian rock types found in Anglesey and Ll■n. They include the major mapped units of Greenly (1920). The aim is to provide the best and most accessible exposure of the rock type. These can be considered as RIGS 'type sections'. Where there is a relevant metamorphic, mineralogical, sedimentary, structural or other change across an outcrop, several representative sites have been chosen. In this study, Porth Trefadog belongs to Network 3 (RIGS Precambrian reference sections; see above) and has been chosen to demonstrate important characteristics and variations of spilitic pillow lavas within the Church Bay tuffs and Skerries Group, and lies adjacent to the New Harbour Group Schists. In particular, the Porth Trefadog exposures demonstrate the effects of metasomatic replacement of spilite minerals by dolomite, copper and manganese and deposition of these minerals as separate entities.

References:

BLAKE, J.F. (1888) On the Monian system of rocks. Quarterly Journal of the Geological Society of London, 44, 271–290.

CARNEY, J.N., HORÁK, J.M., PHARAOH, T.C., GIBBONS, W., WILSON, D., BARCLAY, W.J., BEVINS, R.E, COPE, J.C.W. & FORD, T.D. (2000) Precambrian Rocks of England and Wales. Geological Conservation Review Series No. 20. JNCC, Peterborough, 252pp.

FITCH, F. J., MILLER, J. A., & MENEISY, M. Y. (1963). Geochronological investigations on rocks from North Wales. Nature, London, 199, 449–451.

GIBBONS, W. (1983). Stratigraphy, subduction and strike-slip faulting in the Mona Complex of North Wales – a review. Proceedings of the Geologists' Association,94, 147–163.

GIBBONS, W. & BALL, M. J. 1991. A discussion on Monian Supergroup stratigraphy in northwest Wales. Journal of the Geological Society of London, 148, 5–8.

GIBBONS, W. & HORAK, J. (1990). Contrasting metamorphic terranes in northwest Wales. In : D'LEMOS, R. S., STRACHAN, R. A. & TOPLEY, C. G. (eds) The Cadomian Orogeny. Special Publication of the Geological Society of London, 51, 315–327.

GIBBONS, W. & MANN, A. 1983. Pre-Mesozoic lawsonite in Anglesey, northern Wales; preservation of ancient blueschists. Geology, 11, 3–6.

GREENLY, E. (1919). The geology of Anglesey. Memoirs of the Geological Survey of Great Britain. HMSO, London, 980pp. (2 vols)

GREENLY, E. (1920). 1:50,000 (and 1 inch to 1 mile) Geological Map of Anglesey. Geological Survey of Great Britain, Special Sheet No. 92 and (93 with parts of 94, 105 and 106).

MILLER, J. A. & FITCH, F. J. (1964). Potassium-argon methods with special reference to basic igneous rocks. Quarterly Journal of the Geological Society of London, 120S, 55–69.

MOORBATH, S. & SHACKLETON, R. M. (1966) Isotopic ages from the Precambrian Mona Complex of Anglesey, North Wales (Great Britain). Earth and Planetry Science Letters, 1, 113–117.

SHACKLETON, R. M. (1969). The Precambrian of North Wales. In WOOD, A. (ed.) The Precambrian and Lower Palaeozoic rocks of Wales. University of Wales Press, Cardiff, 1–22.

SHACKLETON, R. M. (1975). Precambrian rocks of Wales. In: HARRIS, A. L., SHACKLETON, R. M., WATSON, J., DOWNIE, C., HARLAND, W. B. & MOORBATH, S. (eds) Precambrian. A correlation of Precambrian rocks in the British Isles. Geological Society Special Report 6, 76–82.

TUCKER. R.D. & PHARAOH, T.C. (1991). U-Pb zircon ages for Late Precambrian igneous rocks in southern Britain. Journal of the Geological Society of London,148, 435–43.

WOOD, D. S. (1974). Ophiolites, melanges, blueschists and ignimbrites; early Caledonian subduction in Wales? In: DOTT, R. R. & SHAVER, R. H. (eds) Modern and Ancient Geosynclinal Sedimentation. Society of Economic Palaeontologists and Mineralogists, Special Publication, 19, 334–344.